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Suzuki et al.

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(54) **COUPLING STRUCTURE FOR VACUUM EXHAUST DEVICE AND VACUUM EXHAUST SYSTEM**

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See application file for complete search history.

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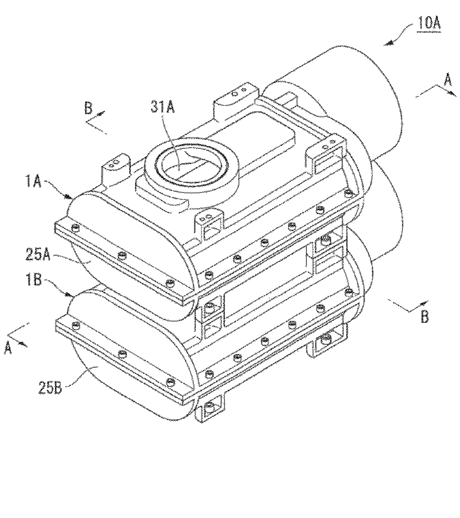
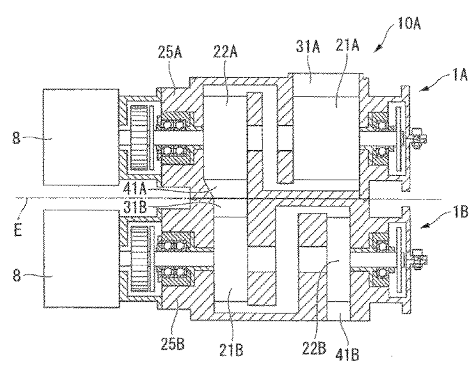
Primary Examiner — Theresa Trieu
(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57) **ABSTRACT**

Provided is a coupling structure for vacuum exhaust devices each including a pump chamber and a casing that demarcates the pump chamber. The coupling structure includes a first end surface formed on a first side of the casing, and a second end surface formed on the second side of the casing, the second side being the opposite side of the first side. The casing of a first vacuum exhaust device and the casing of a second vacuum exhaust device among a plurality of vacuum exhaust devices are arranged to be directly superposed on each other such that the first end surface provided to the first vacuum exhaust device and the second end surface provided to the second vacuum exhaust device come into contact with each other. By fastening the first end surface and the second end surface, the first vacuum exhaust device and the second vacuum exhaust device are connected to each other such that gas can flow between the casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device.

7 Claims, 11 Drawing Sheets





(51) **Int. Cl.**

F04C 2/00	(2006.01)
F01D 25/24	(2006.01)
F04C 11/00	(2006.01)
F04C 2/12	(2006.01)
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F01C 21/10	(2006.01)
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F01C 21/00	(2006.01)
F01C 1/12	(2006.01)
F01C 1/08	(2006.01)
F04C 18/12	(2006.01)

(52) **U.S. Cl.**
CPC ***F04C 2/126*** (2013.01); ***F04C 11/001*** (2013.01); ***F04C 23/00*** (2013.01); ***F04C 23/001*** (2013.01); ***F04C 25/02*** (2013.01); *F01C 1/084* (2013.01); *F01C 1/126* (2013.01); *F04C 18/126* (2013.01)

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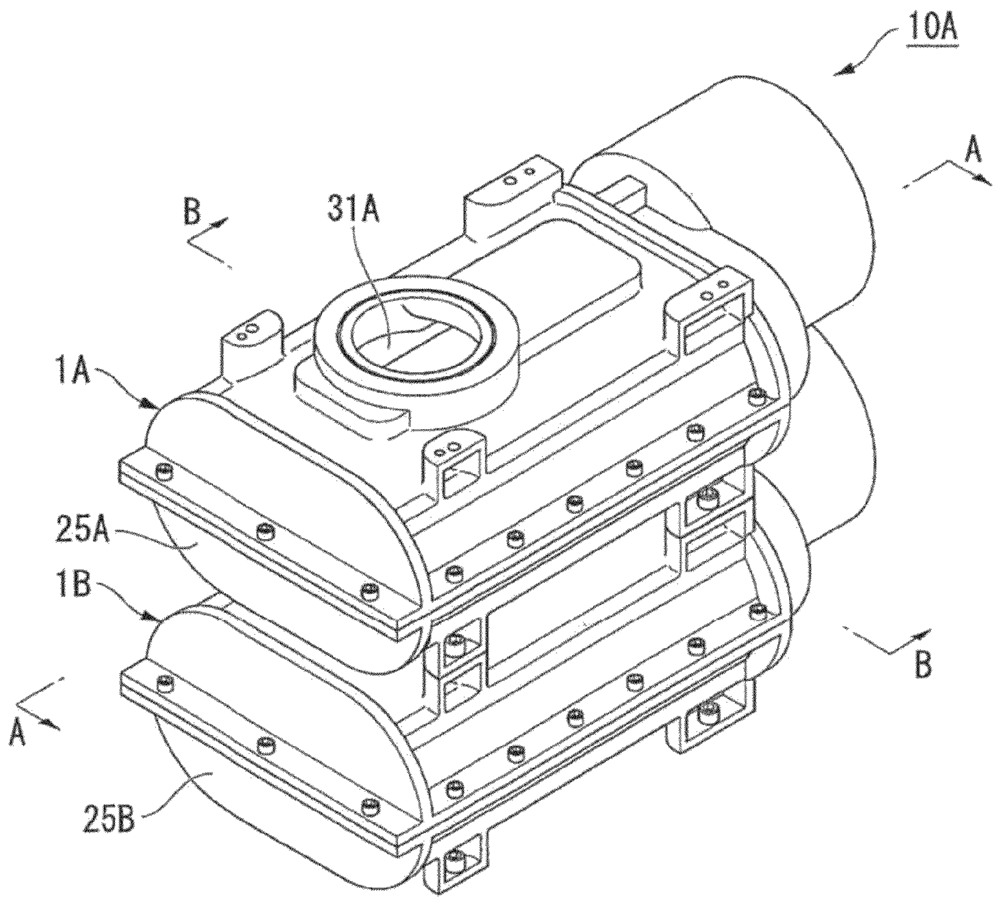
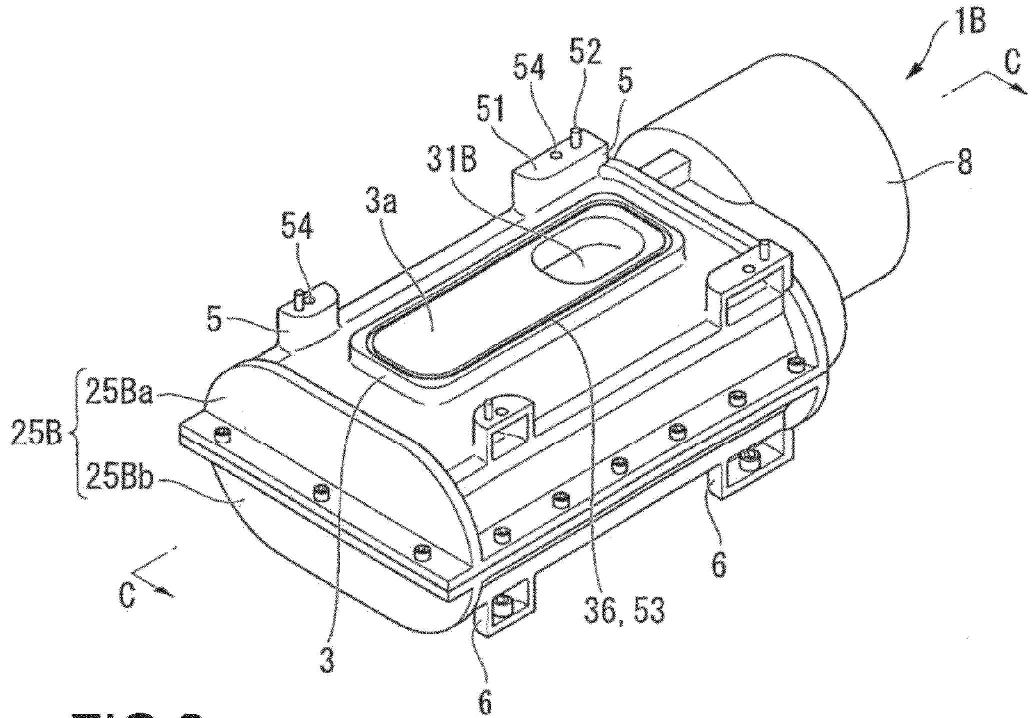


FIG.1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C
54
52
5
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31B
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54
5
25Ba
25B
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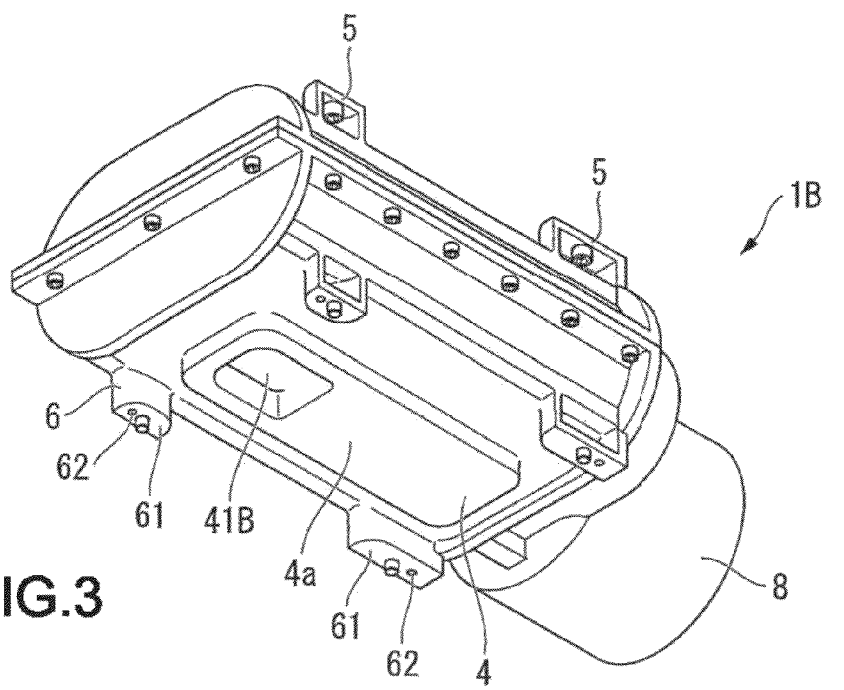
C
6
36, 53
3
6

FIG.2


5
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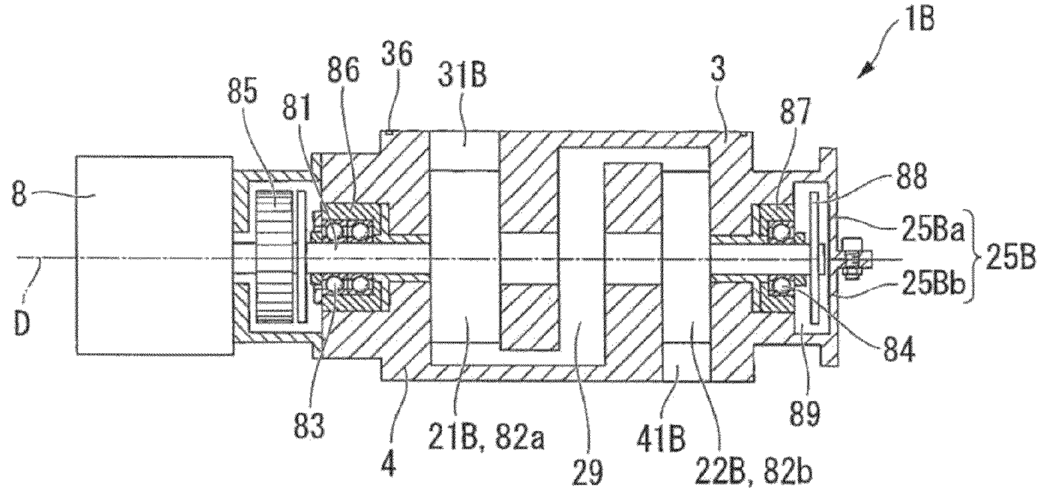
1B
6
62
61
41B
4a
61
62
4
8

FIG.3



1B
85
81
86
36
31B
3
87
88
8
25Ba
25B
25Bb
D
84
89
83
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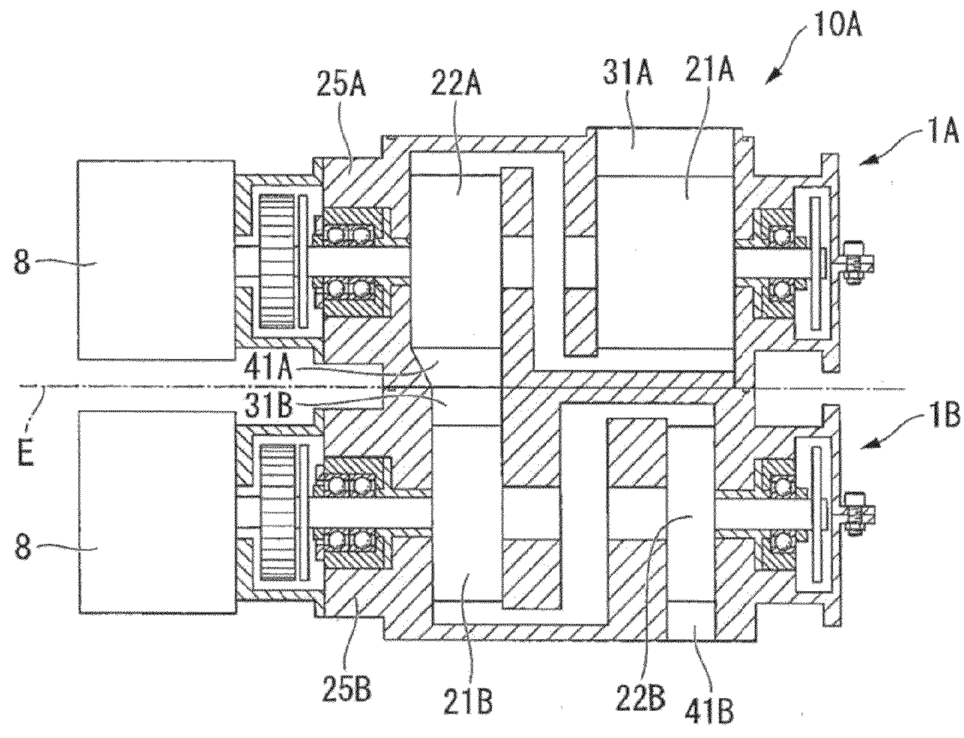
21B, 82a
29
41B
22B, 82b

FIG.4



10A
25A
22A
31A
21A
1A
8
41A
31B
E
1B
8
25B
21B
22B
41B

FIG.5

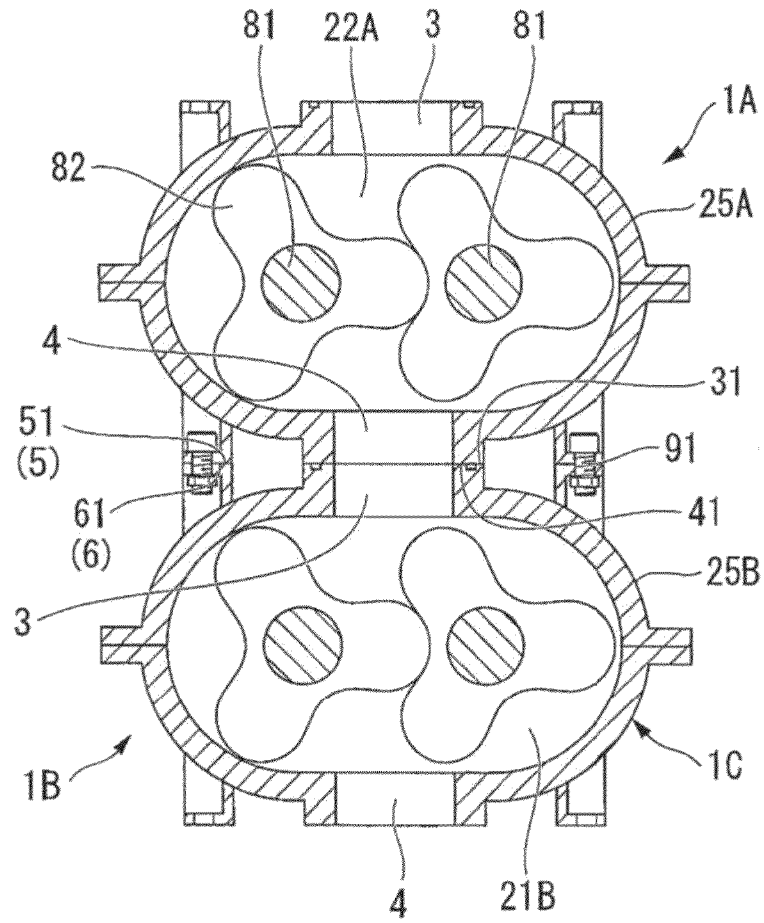


FIG.6

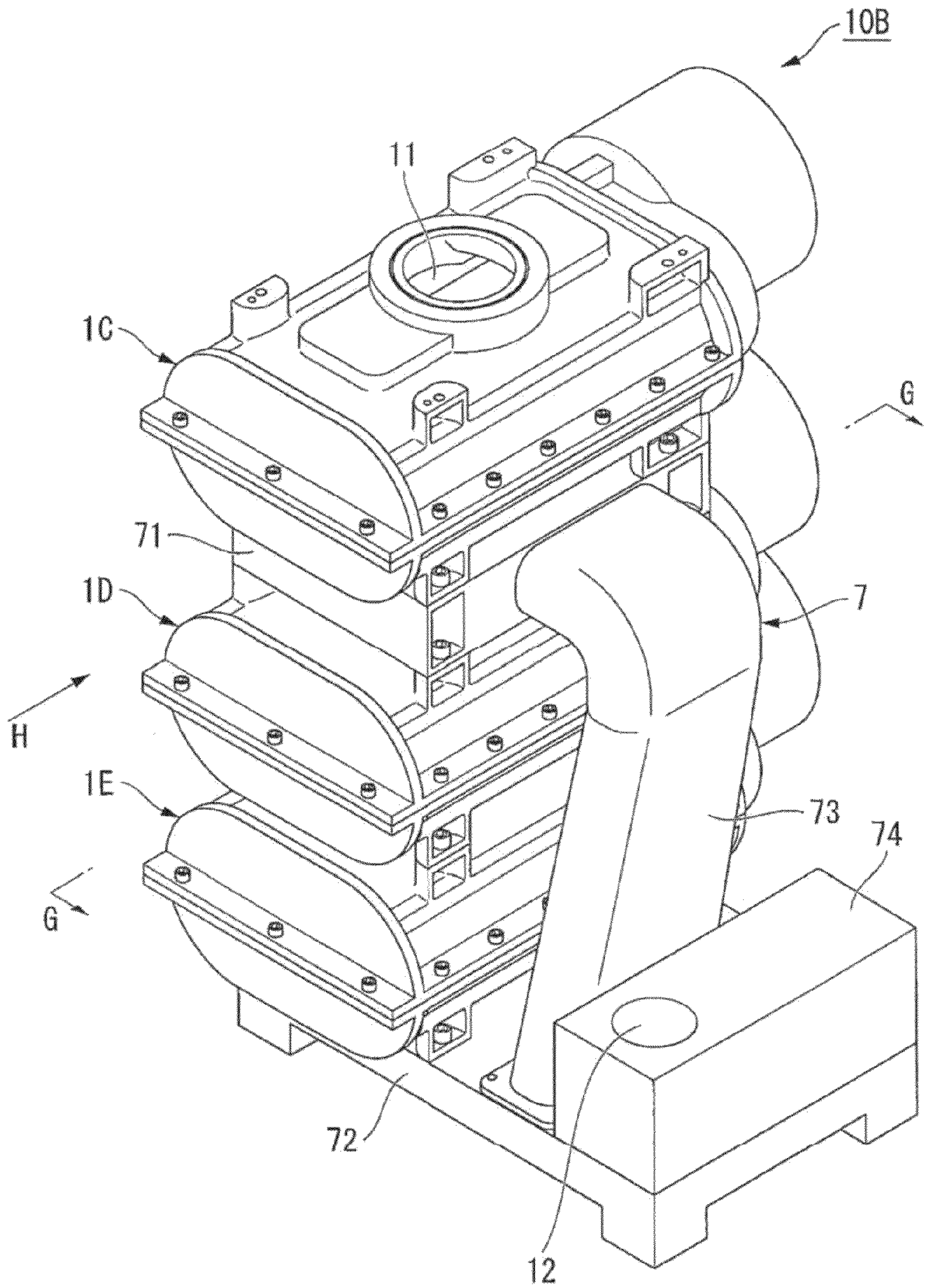
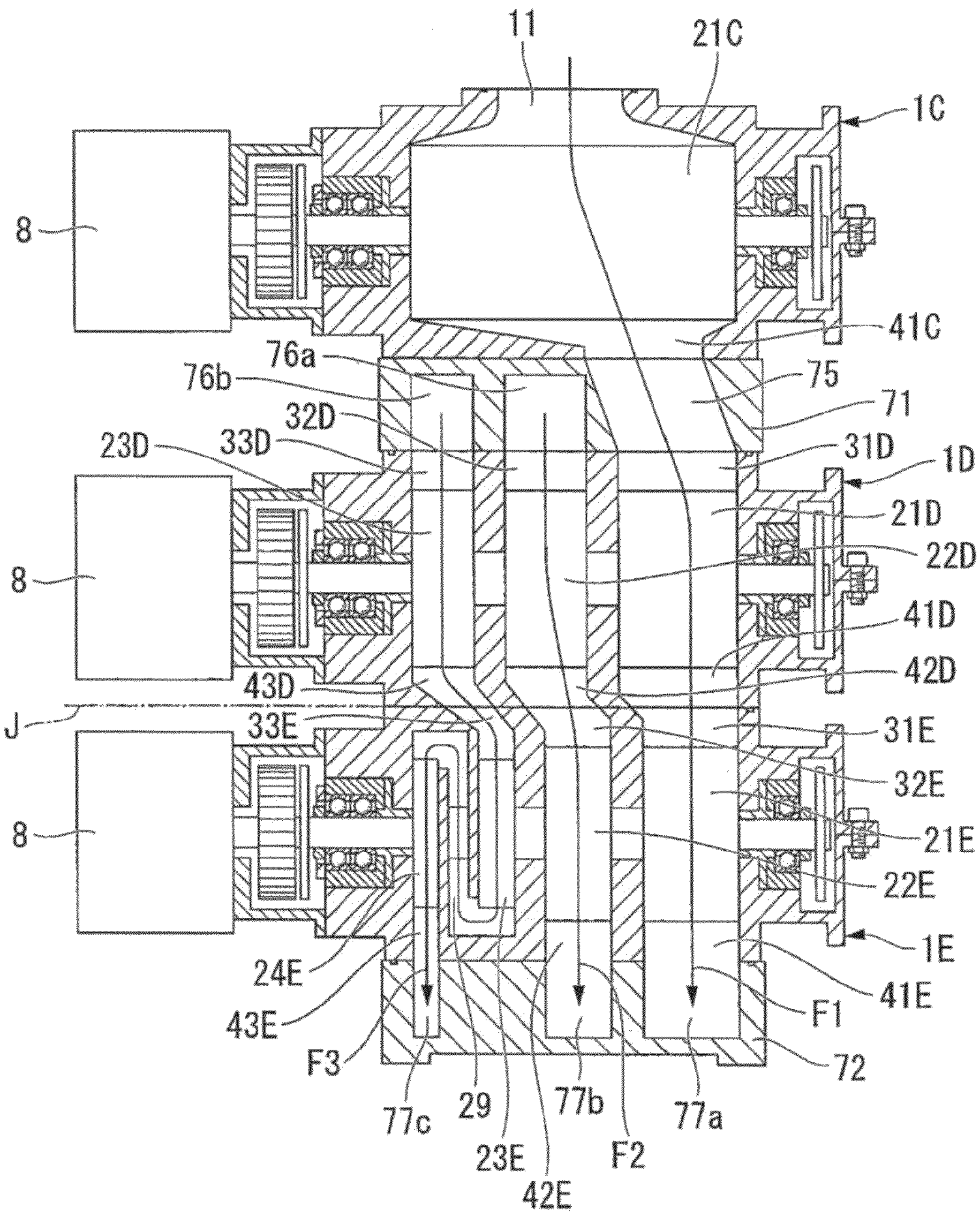


FIG.7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41C
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76b
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71
32D
33D
23D
31D
1D
21D
22D
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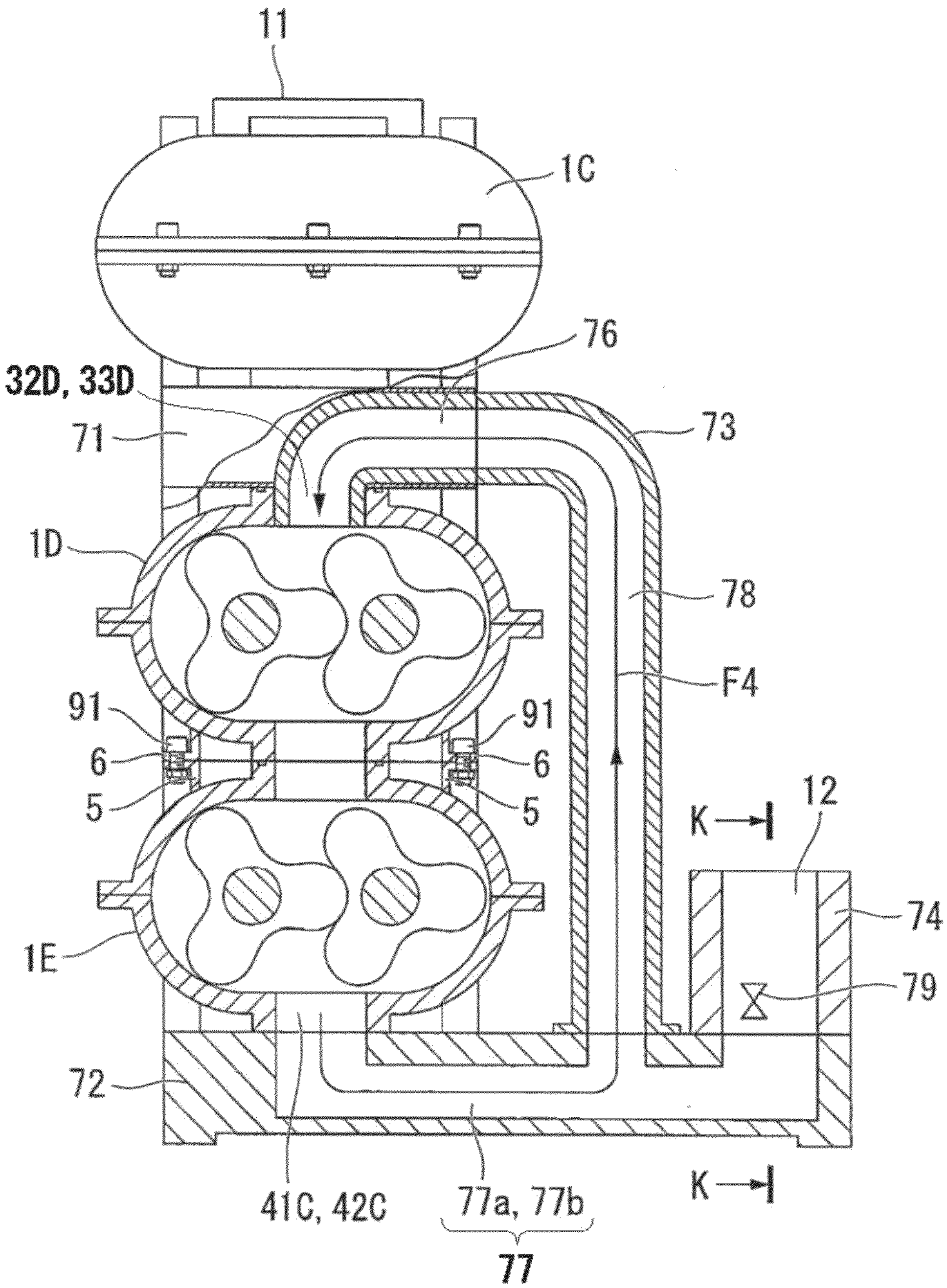
41D
42D
43D
J
33E
31E
32E
21E
8
22E
1E
24E
41E
43E
F1
F3
72
77c
29
77b
77a
23E
F2
42E

FIG.8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77a, 77b
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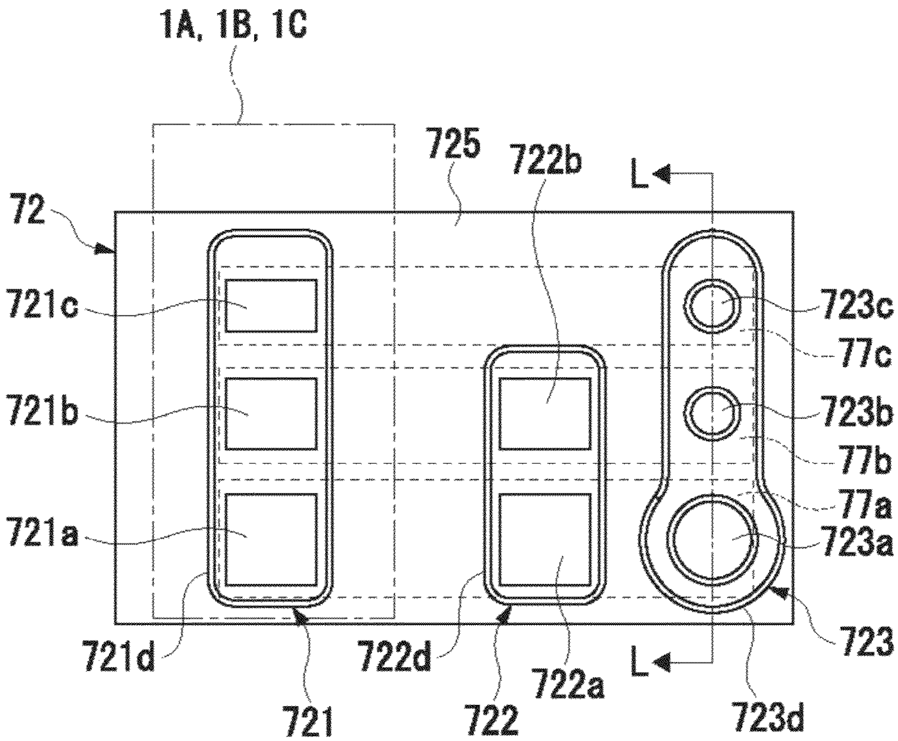
FIG.9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721b
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77a
721a
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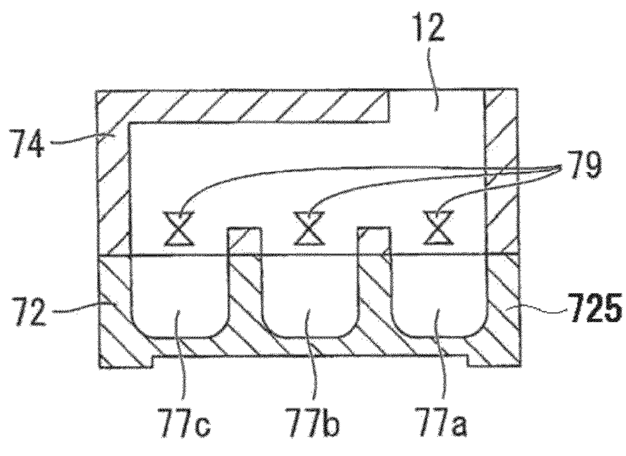
722a
721
722
723d

FIG.10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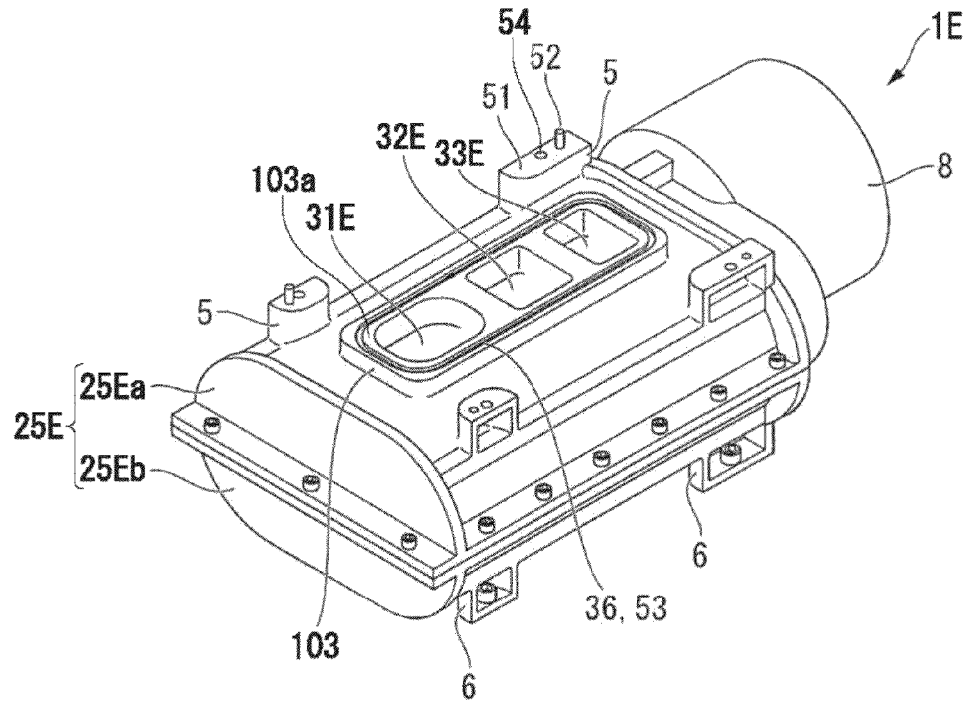
77b
77a

FIG.11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32E
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103a
31E
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25Ea
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25Eb
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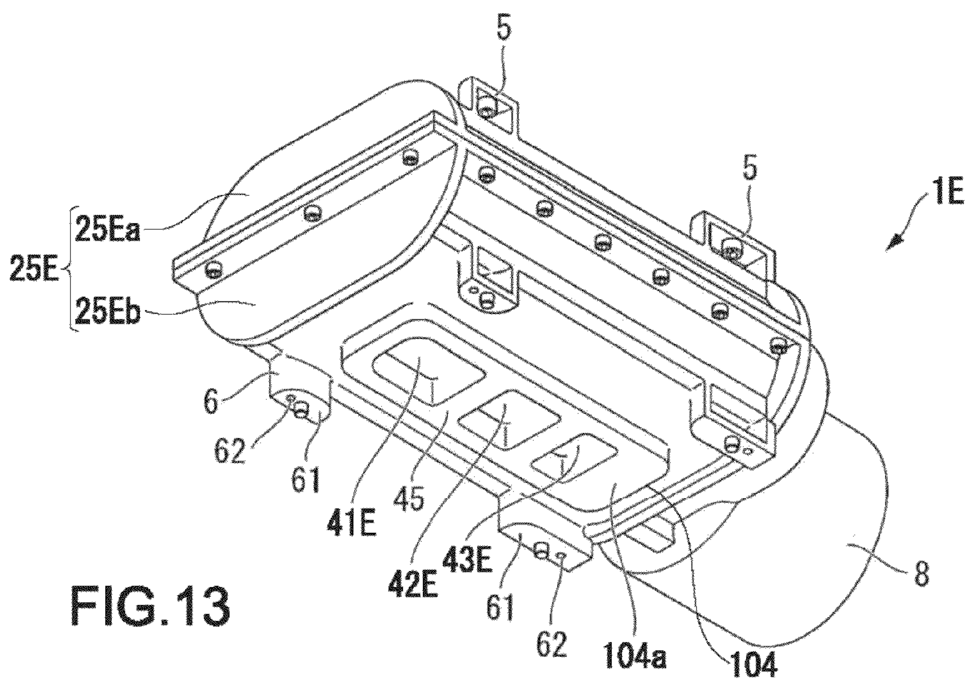
36, 53
103
6

FIG.12


5
5
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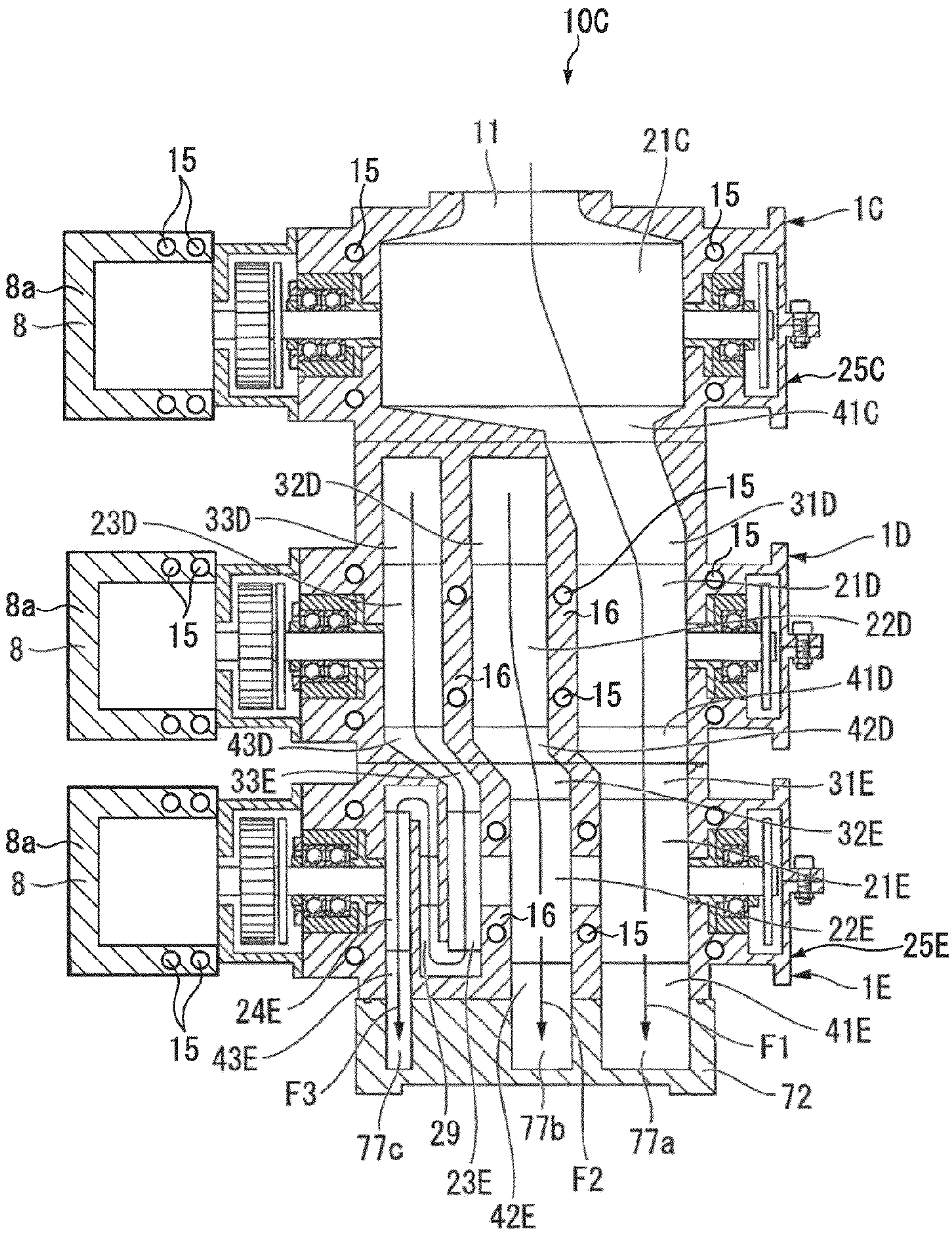
25Ea
25E
25Eb
6
62
61
45
41E
42E
43E
61
8
62
104a
104

FIG.13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1C
8a
8
25C
41C
32D
33D
23D
31D
1D
21D
22D
16
41D
42D
43D
33E
31E
32E
21E
22E
25E
1E
24E
43E
41E
F1
F3
72
77c
29
77b
77a
23E
F2
42E

FIG.14

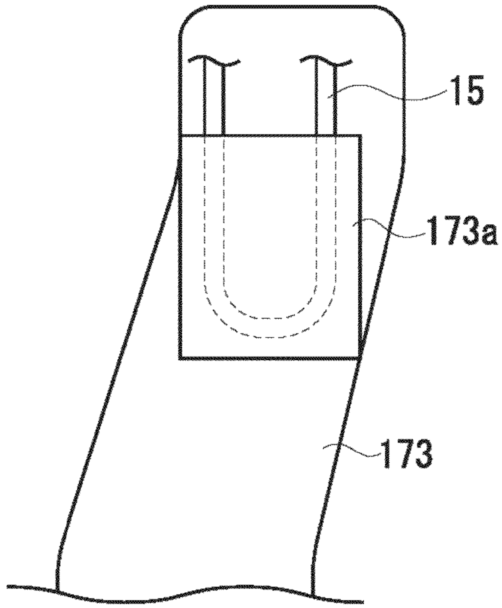

FIG.15

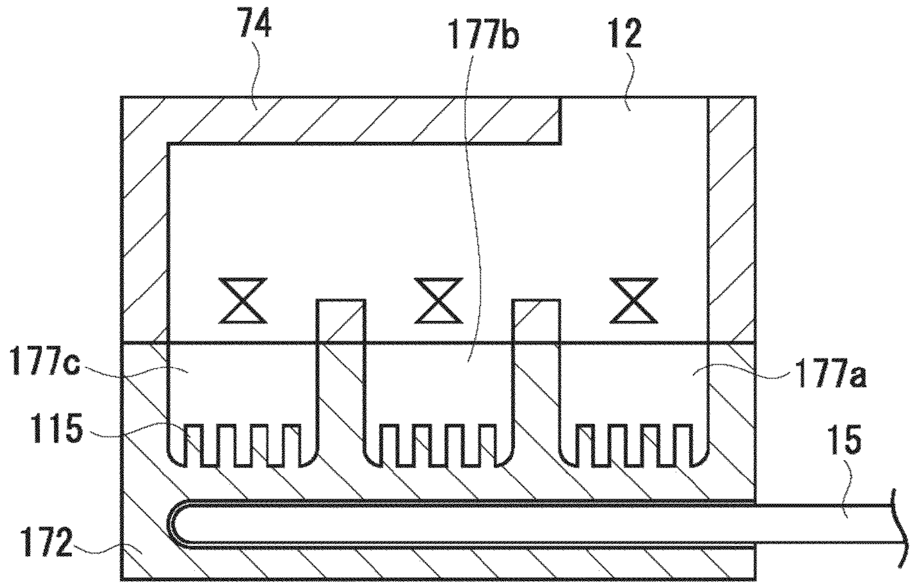

FIG.16

COUPLING STRUCTURE FOR VACUUM EXHAUST DEVICE AND VACUUM EXHAUST SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. national stage application of International Patent Application No. PCT/JP2011/006397, filed Nov. 16, 2011, which claims priority to Japanese Application No. 2010-257141, filed Nov. 17, 2010, the disclosures of each of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to a coupling structure for vacuum exhaust devices, in which a plurality of vacuum exhaust devices that depressurize and exhaust a device to be exhausted such as a vacuum chamber are coupled to one another, and to a vacuum exhaust system provided, to the coupling structure.

This application claims priority based on Japanese Patent Application No 2010-257141, filed in the Japan Patent Office on Nov. 17, 2010, the content of which is incorporated herein by reference.

BACKGROUND ART

In a vacuum exhaust device (vacuum pump) used for depressurizing and exhausting a device to be exhausted such as a vacuum chamber, it is general to connect a plurality of vacuum exhaust devices, which are different depending on the intended use, to one another in series such that gas can flow, thus achieving target performance. For example, a mechanical booster pump is adopted as a main pump for exhausting a device to be exhausted to an operating pressure and maintaining the pressure, and an oil rotary pump or a dry pump is adopted as a roughing pump for exhausting a vacuum system from an, atmospheric pressure to a pressure at which the main pump is capable of operating. Those vacuum pumps are used in combination, thus establishing a vacuum exhaust system with which target performance is achieved. The combination of vacuum pumps is not limited thereto and is diverse. There is a case where three or more vacuum pumps are combined.

In the case where such a plurality of vacuum pumps are combined, the respective vacuum pumps are generally arranged at proper positions and then connected to one another by a connection pipe or the like. For example, a connection structure in which each vacuum pump is fixed to a predetermined frame (installation base) and an exhaust port of the main pump and an intake port of the roughing pump are connected to each other with use of a pipe is generally used.

For example, Non-patent Document 1 below describes a vacuum exhaust system in which an exhaust port of an upper pump and an intake port of a lower pump are connected to each other with use of a pipe. Further, Non-patent Document 2 below describes a vacuum exhaust system in which vacuum pumps are installed on and within a frame and an exhaust port and an intake port of upper and lower vacuum pumps are connected to each other with use of a pipe.

Further, for vacuum pumps connected by the method as described above, widely used is a multistage roots vacuum pump having a multistage structure in which a space formed within a single casing is partitioned to form a plurality of pump chambers. In the multistage roots vacuum pump, it is general to connect pump chambers at respective stages in series (see Patent Document 1 below).

Patent Document 1: Japanese Patent Application Laid-open No 2002-364569

Non-patent Document 1: “Edwards vacuum product catalog Revision 3”. Edwards Japan Limited, p. 54

Non-patent Document 2: “Vacuum Technology and Innovative Ideas (ULVAC): Oil Rotary Vacuum Pump System, YM-VD/YM-VS Series (1580 L/min to 20000 L/min)”, [online], ULVAC, Inc., [retrieved on Apr. 16, 2010], Internet <URL: http://www.ulvac.co.jp/products/compo/F020006.html>

DISCLOSURE OF THE INVENTION

Problem to be Solved by the Invention

Incidentally, in the conventional vacuum exhaust system as described above, in general, the vacuum pumps are individually designed and manufactured except for some specifications such as connection specifications of an exhaust port and an intake port. In the case where such vacuum pumps are installed, in order to effectively use a limited installation space, it is required to make an installation area for installing the vacuum exhaust system as small as possible. Further, as a frame used for installation, it is required to use a frame that is simplified as much as possible and has durability. Furthermore, in order to minimize a pressure loss, pipes to connect the vacuum pumps are required to be short and thick and to be connected so as not to bent.

However, it has been difficult to meet those demands at the same time mainly in view of costs. For example, in consideration of costs, the frame has had to be provided with an enough dimension to support various shapes of vacuum pumps. Further, it has been, impossible to effectively use a limited installation space, for example, the installation area is increased depending on the frame even though the vacuum pump is downsized.

The present invention has been made in view of the circumstances as described above, and it is an object of the present invention to provide a vacuum exhaust device capable of achieving space-saving and cost reduction.

Means for Solving the Problem

In order to achieve the object described above, the present invention provides the following means.

A coupling structure for vacuum exhaust devices according to an embodiment of the present invention is a coupling structure for vacuum exhaust devices each including a pump chamber and a casing that demarcates the pump chamber.

Each of the vacuum exhaust devices includes a motor connected to the casing.

The coupling structure includes a first end surface formed on a first side of the casing and a second end surface formed on a second side of the casing, the second side being the opposite side of the first side.

The casing of a first vacuum exhaust device and the casing of a second vacuum exhaust device among a plurality of vacuum exhaust devices are arranged to be directly superposed on each other such that the second end surface provided to the first vacuum exhaust device and the first end surface provided to the second vacuum exhaust device come into contact with each other.

By fastening the first end surface and the second end surface, the first vacuum exhaust device and the second vacuum exhaust device are connected to each other such that gas can flow between the casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device.

The plurality of vacuum exhaust devices may each include an intake unit and an exhaust unit.

The intake unit includes at least one intake port and an intake unit end surface, the at least one intake port communicating with the pump chamber, and is formed on the first side of the casing.

The exhaust unit includes at least one exhaust port and an exhaust unit end surface, the at least one exhaust port communicating with the pump chamber, and is formed on the second side of the casing.

The casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device are arranged to be directly superposed on each other such that the intake unit, end surface of the intake unit and the exhaust unit end surface of the exhaust unit come into contact with and overlap each other.

By fastening the first end surface and the second end surface, the intake unit end surface and the exhaust, unit end surface are directly connected to each other and the intake port and the exhaust port communicate with each other.

The coupling structure may further include a plurality of mount portions and a plurality of leg portions.

The plurality of mount portions each include the first end surface and are each formed on the first side of the casing.

The plurality of leg portions each include the second end surface and are each formed on the second side of the casing.

The plurality of mount portions and the intake unit may be independently formed on the casing. Further, the plurality of leg portions and the exhaust unit may be independently formed on the casing.

The intake unit end surface of the intake unit and the plurality of mount portions may be formed on the same plane. Further, the exhaust unit end surface of the exhaust unit and the plurality of leg portions may be formed on the same plane.

The coupling structure may further include a sealing member provided to the intake unit end surface or the exhaust unit end surface, the sealing member keeping air sealing inside the casing.

The coupling structure may further include a positioning mechanism provided to the first end surface of each of the plurality of mount portions or the second end surface of each of the plurality of leg portions, the positioning mechanism having a concavo-convex shape.

The casing may be formed of a lower-side casing and an upper-side casing that can be divided into two in a vertical direction.

A vacuum exhaust system according to an embodiment of the present invention is a vacuum exhaust system including a plurality of connected vacuum exhaust devices, the plurality of vacuum exhaust devices each including a pump chamber and a casing that demarcates the pump chamber.

The casing includes a first end surface formed on a first side of the casing and a second end surface formed on a second side of the casing, the second side being the opposite side of the first side.

The casing of a first vacuum exhaust device and the casing of a second vacuum exhaust device among a plurality of vacuum exhaust devices are arranged to be directly superposed on each other such that the second end surface provided to the first vacuum exhaust device and the first end surface provided to the second vacuum exhaust device come into contact with each other.

By fastening the first end surface and the second end surface, the first vacuum exhaust device and the second vacuum exhaust device are connected to each other such that gas can flow between the casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device.

The vacuum exhaust system may further include a connection unit and a cooling mechanism provided at least to the connection unit.

The connection unit is provided to the outside of the casing of each of the plurality of vacuum exhaust devices and causes, among the plurality of vacuum exhaust devices, the pump chamber provided to one of vacuum exhaust devices at subsequent stages after a vacuum exhaust device at a foremost stage and the pump chamber provided to a vacuum exhaust device at a last stage to communicate with each other, the vacuum exhaust device at the foremost stage being connected to a device to be vacuum-exhausted.

The plurality of vacuum exhaust devices may each include an intake unit and an exhaust unit.

The intake unit includes at least one intake port and an intake unit end surface, the at least one intake port communicating with the pump chamber, and is formed on the first side of the casing.

The exhaust unit includes at least one exhaust port and an exhaust unit end surface, the at least one exhaust port communicating with the pump chamber, and is formed on the second side of the casing.

The casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device are arranged to be directly superposed on each other such that the intake unit end surface of the intake unit and the exhaust unit end surface of the exhaust unit come into contact with and overlap each other.

By fastening the first end surface and the second end surface, the intake unit end surface and the exhaust unit end surface are directly connected to each other and the intake port and the exhaust port communicate with each other.

The connection unit may include an intake-side-path-forming member, an exhaust-side-path-forming member, and a pipe member.

The intake-side-path-forming member includes an intake-side path that communicates with the intake port of the first vacuum exhaust device, the intake-side-path-forming member being connected to the casing of the first vacuum exhaust device.

The exhaust-side-path-forming member includes an exhaust-side path that communicates with the exhaust port of the second vacuum exhaust device, the exhaust-side-path-forming member being connected to the casing of the second vacuum exhaust device.

The pipe member includes a pipe path that communicates with the intake-side path and the exhaust-side path, the pipe member being connected to the intake-side-path-forming member and the exhaust-side-path-forming member.

The cooling mechanism may be provided to at least one of the exhaust-side-path-forming member and the pipe member.

The plurality of vacuum exhaust devices may be arranged to be stacked on each other. In this case, the exhaust-side-path-forming member is arranged at a lower portion of the vacuum exhaust device at the last stage, the lower portion being a lowermost portion of the plurality of vacuum exhaust devices.

The connection unit may cause the pump chamber of the first vacuum exhaust device and the pump chamber of the second vacuum exhaust device to communicate with each other.

At least one of the plurality of vacuum exhaust devices may include a partition wall formed within the casing such that a plurality of pump chambers are defined within the casing of the at least, one vacuum exhaust device. The cooling mechanism may further be provided to the partition wall.

Effect of the Invention

According to the embodiments of the present invention, since the casings of the vacuum exhaust devices can be directly coupled to each other without using a frame or the like, it is possible to provide a vacuum exhaust device capable of achieving space-saving and cost reduction.

Further, since the casings of the vacuum exhaust devices are connected to each other, the rigidity of the whole system constituted of a plurality of vacuum exhaust devices is improved, and heat radiated from the vacuum exhaust devices can be dissipated.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of a vacuum exhaust system according to a first embodiment of the present invention as viewed from above.

FIG. **2** is a perspective view of a vacuum exhaust device according to the first embodiment as viewed from above.

FIG. **3** is a perspective view of the vacuum exhaust device as viewed from below.

FIG. **4** is a cross-sectional view of the vacuum exhaust device taken along the line C-C of FIG. **2**.

FIG. **5** is a cross-sectional view of the vacuum exhaust system taken along the line A-A of FIG. **1**.

FIG. **6** is a cross-sectional view of the vacuum exhaust system taken along the line B-B of FIG. **1**.

FIG. **7** is a perspective view of a vacuum exhaust system according to a second embodiment of the present invention as viewed from above.

FIG. **8** is a cross-sectional view of the vacuum exhaust system taken along the line G-G of FIG. **7**.

FIG. **9** is a side view of the vacuum exhaust system as viewed in an H direction of FIG. **7**.

FIG. **10** is a cross-sectional view of a base unit as viewed from, above.

FIG. **11** is a cross-sectional view taken along the line L-L of FIG. **10**.

FIG. **12** is a perspective view of a vacuum exhaust device as viewed from above.

FIG. **13** is a perspective view of the vacuum exhaust device shown in FIG. **12** as viewed from below.

FIG. **14** is a cross-sectional view showing a vacuum exhaust system according to a third embodiment of the present invention.

FIG. **15** is a side view of a pipe member constituting a part of a connection unit of the vacuum exhaust system.

FIG. **16** is a view for describing a cooling mechanism provided to a vacuum exhaust system according to a fourth embodiment of the present invention.

MODE(S) FOR CARRYING OUT THE INVENTION

First Embodiment

Hereinafter, detailed description will be given on a vacuum exhaust system **10**A with reference to the drawings, the vacuum exhaust system **10**A adopting a coupling structure for vacuum exhaust devices according to a first embodiment of the present invention. As shown in FIG. **1**, the vacuum exhaust system **10**A of this embodiment is a system in which two vacuum exhaust devices **1**A and **1**B are coupled to each

other. The vacuum exhaust system **10**A is a system in which gas taken in from an intake port **31**A of the vacuum exhaust device **1**A connected to a device to be exhausted such as a vacuum chamber (not shown) is compressed by the two vacuum exhaust devices **1**A and **1**B and exhausted from an exhaust port **41**B (see FIG. **5**) of the vacuum exhaust device **1**B.

The vacuum exhaust devices **1**A and **1**B constituting the vacuum exhaust system **10**A each have a casing as a constituent element, the casing having substantially the same outer shape. Further, the vacuum exhaust device **1**A (first vacuum exhaust device) can be arranged to be directly superposed on the vacuum exhaust device **1**B (second vacuum exhaust device) on a plane denoted by a reference symbol E (see FIG. **5**).

Further, the vacuum exhaust device **1**A is arranged to be superposed on the vacuum exhaust device **1**B so as to be stacked in an up-and-down direction (vertical direction), and thus an exhaust port **41**A of the vacuum exhaust device **1**A on the upper side (see FIG. **5**) and an intake port **31**B of the vacuum exhaust device **1**B on the lower side can be directly connected to each other without a pipe.

Hereinafter, detailed description will be given on each of the vacuum exhaust devices **1**A and **1**B. The vacuum exhaust device **1**A and the vacuum exhaust device **1**B have substantially the same configuration, and therefore the vacuum exhaust device **1**B will be described.

As shown in FIGS. **2** to **4**, the vacuum exhaust device **1**B is, a roots vacuum pump including a casing **25**B constituted of an upper-side casing **25**Ba and a lower-side casing **25**Bb, two rotating shafts **81** and **81** (see FIG. **6**), cocoon-shaped rotors **82***a* and **82***b* that are housed in two pump chambers **21**B and **22**B, respectively, the pump chambers **21**B and **22**B being demarcated by the casing **25**B, and a motor **8** that drives the rotating shafts **81** and **81**.

The rotors **82***a* and **82***b* are each constituted of a pair of rotors. The two rotors are arrayed on the respective rotating shafts **81** and housed in the pump chambers **21**B and **22**B. The pair of rotors are synchronously rotated in different directions by a drive gear **85** provided at a shaft end of each rotating shaft **81**.

The casing **25**B demarcates the two pump chambers **21**B and **22**B and also forms the outer shape of the vacuum exhaust device **1**B. Further, the rotating shafts **81** and **81** are supported by bearings **83** and **84**.

The pump chamber **21**B and the pump chamber **22**B are directly connected to each other via a connection pipe **29** on the inside of the casing **25**B constituting the vacuum exhaust device **1**B. The pump chamber **21**B communicates with the intake port **31**B formed at an upper portion of the casing **25**B. The pump chamber **22**B communicates with the exhaust port **41**B formed at a lower portion of the casing **25**B.

Next, description will be given on the casing **25**B constituting the vacuum exhaust device **1**B. The casing **25**B has a vertically dual-partitioning structure as will be described later, in which an intake unit **3** including the intake port **31**B is formed in an upper portion (first side), and an exhaust unit **4** including the exhaust port **41**B is formed in the lower portion (second side). Further, four mount portions **5** are formed in the upper portion (first side) of the casing **25**B, and four leg portions **6** are formed in the lower portion (second side).

The casing **25**B has an elliptical cylinder shape that depends on the shape of the pump chambers **21**B and **22**B. The intake unit **3**, the exhaust unit **4**, the mount portions **5**, and the leg portions **6** are formed integrally with the casing **25**B.

Specifically, it is preferable to form the intake unit **3**, the exhaust unit **4**, the mount portions **5**, and the leg portions **6** integrally by molding.

The vacuum exhaust device **1**B is provided such that the longitudinal direction of the casing **25**B (axial direction of the rotating shaft **81**) is horizontal. It should be noted that in the following description, the plane including the two rotating shafts **81** is referred to as a horizontal center plane (denoted by D in FIG. **4**).

The casing **25**B is divided into two of the upper-side casing **25**Ba and the lower-side casing **25**Bb. The upper-side casing **25**Ba and the lower-side casing **25**Bb are fastened with fastener members such as a bolt and a nut and are configured so as to be capable of holding a bearing case **86** on the motor **8** side and a bearing case **87** on the other side of the motor side by the combination of the upper- and lower-side casings **25**Ba and **25**Bb. Further, the combination of the upper- and lower-side casings **25**Ba and **25**Bb allows a space **89** including the bearing **84** located on the other side of the motor side and an oil scrape-up blade **88** to be hermetically sealed. It should be noted that in this embodiment, the division plane substantially coincides with the horizontal center plane D.

The intake unit **3** is formed in the upper portion of the casing **25**B so as to upwardly protrude and formed integrally with the casing **25**B (upper-side casing **25**Ba). The intake unit **3** includes an end surface (intake unit end surface) **3***a* that is parallel to the horizontal center plane D described above. This end surface **3***a* has a substantially rectangular shape that is long in the longitudinal direction of the casing **25**B.

Further, the intake unit **3** is provided with the intake port **31**B. The intake port **31**B is opened on the end surface **3***a* and communicates with the pump chamber **21**B. Furthermore, a groove **36** is formed along the outer shape of the end surface **3***a* on a slightly inner side of the end surface **3***a* of the intake unit **3**. An O-ring **53** (sealing member) is fitted into the groove **36**.

The exhaust unit **4** is formed in the lower portion of the casing **25**B so as to downwardly protrude and formed integrally with the casing **25**B (lower-side casing **25**Bb). Similarly to the intake unit **3**, the exhaust unit **4** includes an end surface (exhaust unit end surface) **4***a* that is parallel to the horizontal center plane D. The exhaust unit **4** is provided with the exhaust port **41**B. The exhaust port **41**B is opened on the end surface **4***a* and communicates with the pump chamber **22**B.

The end surface **3***a* of the intake unit **3** and the end surface **4***a* of the <exhaust unit **4** have substantially the same shape in plan view.

The mount portions **5** serve as the upper portion of the casing **25**B (upper-side casing **25**Ba) and are protrusion-like mounts that are provided at four outermost positions in plan view. The mount portions **5** each have such a protrusion-like shape that protrudes upwardly from the vacuum exhaust device **1**B. An upper end of each of the four mount portions **5** forms a surface **51** (hereinafter, referred to as first end surface **51**). The four first end surfaces **51** are formed on the same plane.

Further, the first end surfaces **51** of the mount portions **5** and the end surface **3***a* of the intake unit **3** described above are formed on the same plane. However, the mount portions **5** are provided independently of the intake unit **3**. In other words, the first end surfaces **51** of the mount portions **5** and the end surface **3***a* of the intake unit **3** are formed separate from each other.

The leg portions **6** serve as the lower portion of the casing **25**B (lower-side casing **25**Bb) and are protrusion-like legs that are provided at four outermost positions in plan view. The leg portions **6** each have such a protrusion-like shape that protrudes downwardly from the vacuum exhaust device **1**B. Further, the positions in plan view are substantially the same as those of the mount portions **5**. A lower end of each of the four leg portions **6** forms a surface **61** (hereinafter, referred to as second end surface **61**). The four second end surfaces **61** are formed on the same plane.

Further, the end surfaces **61** of the leg portions **6** and the end surface **4***a* of the exhaust unit **4** are formed on the same plane. However, the leg portions **6** are provided independently of the exhaust port **4**. In other words, the end surfaces **61** of the leg portions **6** and the end surface **4***a* of the exhaust unit **4** are formed separate from each other.

Moreover, each of the mount portions **5** and leg portions **6** is formed to be hollow with a side surface being as an open surface, and the end surfaces **51** and **61** are provided with fastening holes (positioning holes) **54** and **62**, respectively.

Further, as shown in FIGS. **2** and **3**, the mount portion **5** is provided with a protrusion portion **52** (positioning mechanism). In response to this, the leg portion **6** is provided with a positioning hole **62** (positioning mechanism).

It should be noted that as shown in FIG. **5**, the vacuum exhaust device **1**A has substantially the same configuration as that of the vacuum exhaust device **1**B except for the arrangement of the pump chambers **21**A and **22**A.

As shown in FIG. **5**, the vacuum exhaust system **10**A is a system in which the vacuum exhaust device **1**A is directly superposed on the vacuum exhaust device **1**B. In this case, the vacuum exhaust device **1**A is superposed on the vacuum exhaust device **1**B such that the end surface **3***a* of the intake unit **3** of the vacuum exhaust device **1**B and an end surface **4***a* of the exhaust unit **4** of the vacuum exhaust device **1**A come into contact with each other. Further, the exhaust port **41**A of the vacuum exhaust device **1**A and the intake port **31**B of the vacuum exhaust device **1**B are formed at the same position in plan view.

According to the embodiment described above, the vacuum exhaust devices **1**A and **1**B can be arranged to be directly superposed on each other in the up-and-down direction on the plane denoted by reference symbol E (see FIG. **5**), and the vacuum exhaust device **1**A can be placed immediately above the vacuum exhaust device **1**B such that the end surface **4***a* of the exhaust port **4** of the vacuum exhaust device **1**A comes into contact with and overlaps the end surface **3***a* of the intake unit **3** of the vacuum exhaust device **1**B. Thus, the exhaust port **41**A of the vacuum exhaust device **1**A and the intake port **31**B of the vacuum exhaust device **1**B can communicate with each other such that gas can flow.

In other words, gas that flows in from the intake port **31**A of the vacuum exhaust device **1**A is compressed in the pump chambers **21**A and **22**A and exhausted from the exhaust port **41**A. Then, the gas is compressed in the pump chambers **21**B and **22**B via the intake port **31**B of the vacuum exhaust device **1**B and exhausted from the exhaust port **41**B. In the compression, the gas is trapped in a space between the casing **25** and the rotor **82** and exhausted to the exhaust side by the rotation of the rotor **82**.

Thus, it is unnecessary to provide a pipe that connects the vacuum exhaust devices **1**A and **1**B to each other, and since a distance between the coupled pump chambers becomes short, it is possible to suppress a pressure loss.

Since the casings **25**A and **25**B constituting the vacuum exhaust devices **1**A and **1**B are connected to each other, the rigidity of the whole system constituted of a plurality of vacuum exhaust devices is improved, and heat radiated from the vacuum exhaust devices **1**A and **1**B can be dissipated.

Further, the casing **25** is provided with the configuration in which the upper and lower casings **25***a* and **25***b* are combined with each other to hold the bearing cases **86** and **87** and to form the space **89** on the opposite side of the motor side (to serve as cover). Thus, it is possible to reduce the number of components and suppress deformation of the vacuum exhaust devices **1**A and **1**B at a time of an exhaust operation because the whole casing **25** holds the bearing cases **86** and **87**.

Further, since the first end surfaces **51** of the mount portions **5** and the second end surfaces **61** of the leg portions **6** are formed at, substantially the same positions in plan view, the first end surfaces **51** of the mount portions **5** and the second end surfaces **61** of the leg portions **6** can come into contact with and overlap each other by arranging the vacuum exhaust device **1**A and the vacuum exhaust device **1**B in the up-and-down direction. In this state, the mount portions **5** and the leg portions **6** are fastened with the fastener member **91** such as a bolt and a nut, which makes it possible to reliably fix the vacuum exhaust device **1**A and the vacuum exhaust device **1**B.

By arrangement of the sealing member such as the O-ring **53** in the groove **36** formed on the end surface **3***a* of the intake unit **3**, an airtight state when the intake unit **3** and the exhaust unit **4** are connected can be improved.

It should be noted that the groove **36** may be provided not on the intake unit **3** side but on the exhaust unit **4** side (in this case, on the exhaust unit side of the casing **25**A of the vacuum exhaust device **1**A).

When the vacuum exhaust devices **1**A and **1**B are coupled to each other, the protrusion portion **52** of the mount portion **5** and the positioning hole **62** of the leg portion **6** are fitted to each other so that positioning can be easily performed. The protrusion portion **52** and the positioning hole **62** are preferably provided to all of the leg portions **6** and the mount portions **5**, but may be provided to at least two of the protrusion portions **52** and of the positioning holes **62**.

It should be noted that the number of pump chambers demarcated within the casing **25** may be one or three or more and can be freely set depending on the specifications.

Further, the vacuum exhaust device is not limited to the above-mentioned roots vacuum pump, and any vacuum pump may be adopted as long as it is a vacuum pump having the same structure including an intake port and an exhaust port in a casing.

Further, in this embodiment, the four mount portions **5** and the four leg portions **6** are provided, but the structure is not limited thereto. Any structure may be adopted as long as the mount portion **5** can reliably support the leg portion **6**.

Moreover, if the mount portion **5** can reliably support the leg portion **6**, the first end surface **51** of the mount portion **5** and the end surface **3***a* of the intake unit **3** may be formed integrally with each other, without being formed separated from each other. In the same way, the second end surface **61** of the leg portion **6** and the end surface **4***a* of the exhaust unit **4** may also be formed integrally with each other.

Second Embodiment

Next, detailed description will be given on a vacuum exhaust system **10**B according to a second embodiment of the present invention with reference to the drawings. As shown in FIG. **7**, the vacuum exhaust system **10**B is a system in which gas taken in from an intake port **11** connected to a device to be exhausted such as a vacuum chamber (not shown) is compressed by three vacuum exhaust devices **1**C, **1**D, and **1**E and exhausted from an exhaust port **12**.

As shown in FIGS. **7** and **8**, the vacuum exhaust devices **1**C, **1**D, and **1**E constituting the vacuum exhaust system **10**B can be arranged to be directly superposed on one another. Specifically, casings constituting the vacuum exhaust devices **1**C, **1**D, and **1**E can be directly connected to one another.

As shown in FIG. **8**, among the three vacuum exhaust devices **1**C to **1**E, the vacuum exhaust device **1**C at the foremost stage is a mechanical booster pump including a single pump chamber **21**C in the casing. The vacuum exhaust device **1**C is connected to a device to be exhausted such as a vacuum chamber (not, shown).

The vacuum exhaust devices **1**D and **1**E at the stages subsequent to the foremost stage are each a multistage roots vacuum pump and each include a plurality of pump chambers. Further, the vacuum exhaust devices **1**D and **1**E each include a plurality of intake ports and exhaust ports for the plurality of pump chambers. That is, the plurality of pump chambers constituting the vacuum exhaust device **1**D (**1**E) of this embodiment are not connected such that all the pump chambers are connected in series.

In other words, at least two of the plurality of pump chambers are not connected to another pump chamber formed in the same casing. Further, those pump chambers are each provided with both an intake port and an exhaust port.

A pump chamber **21**D of the vacuum exhaust device **1**D is not connected to the other pump chambers **22**D and **23**D in the same vacuum exhaust device **1**D and is connected to a pump chamber **21**E of the vacuum exhaust device **1**E via an exhaust port **41**D that directly communicates with the pump chamber **21**D.

Further, the vacuum exhaust device **1**D and the vacuum exhaust device **1**E directly communicate with each other on the plane denoted by reference symbol J without using a pipe or the like.

Furthermore, the vacuum exhaust system **10**B includes a connection unit **7** (manifold) that supplements connection among the vacuum exhaust devices **1**. The connection unit **7** is divided into an intake-side-path-forming member (first connection member) **71**, a base unit **72** as an exhaust-side-path-forming member (second connection member), a pipe member **73**, and a valve unit **74** (valve assembly). Those are combined with the vacuum exhaust devices **1**C to **1**E, and thus a connection pipe that connects the plurality of pump chambers constituting the vacuum exhaust devices **1**C to **1**E is completed, thus functioning as the vacuum exhaust system **10**B.

The intake-side-path-forming member **71** is a block-shaped member arranged in between the vacuum exhaust device **1**C and the vacuum exhaust device **1**D. In the intake-side-path-forming member **71**, a path **75** (see FIG. **8**) that connects the pump chamber **21**C of the vacuum exhaust device **1**C and the pump chamber **21**D of the vacuum exhaust device **1**D is formed, and an intake-side path (connection path) **76** (see FIG. **9**) that connects the pipe member **73** and the pump chambers **22**D and **23**D of the vacuum exhaust device **1**D is formed. The pipe member **73** is connected to a side portion of the intake-side-path-forming member **71**, and a pipe path **78** formed within the pipe member **73** is connected to the intake-side path **76**. The intake-side path **76** is constituted of two paths as denoted by reference symbols **76***a* and **76***b* of FIG. **8**.

FIG. **12** is a perspective view of the vacuum exhaust device **1**E (that may be **1**D) as viewed from above. FIG. **13** is a perspective view of this vacuum exhaust device as viewed from below. A casing of the vacuum exhaust device **1**E has a vertically dual-partitioning structure as described above and includes an upper-side casing **25**Ea and a lower-side casing

25Eb. An intake unit **103** is provided to the upper-side casing **25**Ea (see FIG. **12**), and an exhaust unit **104** is provided to the lower-side casing **25**Eb. An O-ring **53** is fitted to an end surface **103***a* of the intake unit **103**, and in addition thereto, a gasket (not shown) is applied to the end surface **103***a* of the intake unit **103**. The gasket is a sealing member for blocking communication of adjacent intake ports **31**E, **32**E, and **33**E with one another.

At the time of manufacture of this vacuum exhaust system **10**B, for example, after a paste-like gasket is applied to the end surface **103***a* of the intake unit **103**, the end surface **103***a* of the casing **25**E comes into contact with an end surface of an exhaust unit of the casing of the vacuum exhaust device **1**D so that those are connected to each other. As a material of the gasket, corrosive-resistant rubber made of silicon-based or fluorine-based rubber is used, but the material is not limited thereto.

By use of a simple sealing member such as a coating-type gasket in this way, it is possible to reduce costs and ensure the intake ports **31**E, **32**E, and **33**E each having as large an opening area as possible within the small intake unit **103**. Even when a simple sealing member is used in this way and gas leaks between adjacent intake ports, there is no problem if the leakage occurs at a leak speed, sufficiently small with respect to an exhaust speed.

In the description above, the example in which the gasket is applied to the end surface **103***a* of the intake unit **103** has been described. However, as a matter of course, the gasket may be applied to the end surface **104***a* of the exhaust unit **104**.

For example, in the case where the flatness of the end surfaces **103***a* and **104***a* is high, if the leakage speed of gas is sufficiently small, the coating-type gasket is unnecessary.

The base unit **72** is arranged so as to be connected to the bottom surface, that is, a lower portion of the vacuum exhaust device **1**E and is connected to the pump chambers constituting the vacuum exhaust system **1**E, the pipe member **73**, and the valve unit **74**. The pump chamber of the vacuum exhaust device **1**C and the pipe member **73** are connected to the base unit **72**, and an exhaust-side path (connection path) **77** (see FIG. **9**) that connects the pump chambers of the vacuum exhaust device **1**E and the valve unit **74** is formed in the base unit **72**. There is provided a structure in which the vacuum exhaust device **1**E, the pipe member **73**, and the valve unit **74** are each connected to an upper surface of the base unit **72**, and the base unit **72** supports the whole vacuum exhaust system **10**B.

The exhaust-side path **77** includes three paths including two paths **77***a* and **77***b* (see. FIG. **8**) connected to the pipe path **78** of the pipe member **73**, and a path **77***c* that connects an exhaust port **43**E and the valve unit **74**, the exhaust port **43**E communicating with a pump chamber **24**E of the vacuum exhaust device **1**E.

The pipe member **73** is a pipe-shaped member, and on the inside thereof, the above-mentioned pipe path **78** that connects the exhaust port of the vacuum exhaust device **1**E and the intake port of the vacuum exhaust device **1**D is formed. The pipe path **78** is divided into two by a division plane along the longitudinal direction, in accordance with two paths corresponding to the paths **76***a* and **76***b* (see FIG. **8**) of the intake-side-path-forming member **71**.

FIG. **10** is a cross-sectional view of the base unit **72** as viewed, from above. FIG. **11** is a cross-sectional view taken along the line L-L of FIG. **10**. On an upper surface of a block **725** of the base unit **72**, a pump connection unit **721** connected to the casing of the vacuum exhaust device **1**E, a pipe connection unit **722** connected to the pipe member **73**, and a valve unit connection unit **723** connected to the valve unit **74** are formed. Seal members **721***d*, **722***d*, and **723***d* such as an O-ring are fitted into annular grooves formed at the circumferences of those pump connection unit **721**, pipe connection unit **722**, and valve unit connection unit **723**, respectively.

In the pump connection unit **721**, three communication ports **721***a*, **721***b*, and **721***c* are formed to be arrayed. Those three communication ports **721***a*, **721***b*, and **721***c* communicate with exhaust ports **41**E, **42**E, and **43**E of the vacuum exhaust device **1**E, respectively. In the pipe connection unit **722**, two communication ports **722***a* and **722***b* are formed and communicate with the pipe path **78** of the pipe member **73**. Further, in the valve unit connection unit **723**, three communication ports **723***a*, **723***b*, and **723***c* are formed to be arrayed.

All of the communication ports **721***a*, **722***a*, and **723***a* communicate with the path **77***a* of the exhaust-side path **77**. All of the communication ports **721***b*, **722***b*, and **723***b* communicate with the path **77***b* of the exhaust-side path. All of the communication ports **721***c* and **723***c* communicate with the path **77***c* of the exhaust-side path. Those configurations are easy to understand also with reference to FIG. **9**.

The valve unit **74** includes a whole exhaust port **12** that is an exhaust port of the whole vacuum exhaust system **10**B. As shown in the cross-sectional view of FIG. **11**, the valve unit **74** is provided with a plurality of valves **79** (check valves). Thus, among the pump chambers **21**E, **22**E, and **24**E constituting the vacuum exhaust device **1**E and directly connected to the exhaust ports **41**E, **42**E, and **43**E, respectively, gas can be exhausted from an arbitrary pump chamber individually.

The valve unit **74** is provided, and therefore it is possible to prevent excessive compression by the pumps and suppress a loss of power transmission by the motor **8**.

Each of the plurality of valves **79** may have a ball shape or may be an adjustment valve capable of adjusting a pressure to an individual value. In the case where each of the valves **79** is an adjustment valve capable of adjustment to an individual pressure, the pressure can be set as appropriate, and a pressure range to be used by a user can be widened.

In this, way, the base unit **72** and the valve unit **74** are arranged at a lower portion of the vacuum exhaust device **1**E at the last stage, that is, arranged at the lowermost portion of the vacuum exhaust system **10**B. Thus, it is possible to arrange the center of gravity of the vacuum exhaust system **10**B as low as possible and to increase stability when the vacuum exhaust system **10**B of the vertically stacked multi-stage is installed.

Next, with reference to FIG. **8**, description will be given on the configuration of the plurality of pump chambers constituting each vacuum exhaust device in this embodiment and a connection order of the pump chambers.

The vacuum exhaust device **1**C located at the uppermost stage is a mechanical booster pump including one pump chamber **21**C, and the pump chamber **21**C includes the intake port **11** and the exhaust port **41**C.

The vacuum exhaust device **1**D includes the three pump chambers **21**D, **22**D, and **23**D. The three pump chambers **21**D, **22**D, and **23**D include the three intake ports **31**D, **32**D, and **33**D and three exhaust ports **41**D, **42**D, and **43**D described above.

The vacuum exhaust device **1**E includes the four pump chambers **21**E, **22**E, **23**E, and **24**E including the three intake ports **31**E, **32**E, and **33**E and the three exhaust ports **41**E, **42**E, and **43**E. Among the four pump chambers of the vacuum exhaust device **1**E, two of the pump chambers **23**E and **24**E are directly connected to each other within the casing, constituting the vacuum exhaust device **1**E via the connection pipe **29**.

The connection unit **7** is configured such that the intake-side-path-forming member **71**, the base unit **72**, and the pipe member **73** work in cooperation with one another to connect the exhaust port **41**E of the vacuum exhaust device **1**E and the intake port **32**D of the vacuum exhaust device **1**D. Similarly, the connection unit **7** is configured such that the exhaust port **42**E of the vacuum exhaust device **1**E and the intake port **33**D of the vacuum exhaust device **1**D are connected.

Further, the connection unit **7** is configured such that the exhaust port **43**E of the vacuum exhaust device **1**E and the valve unit **74** are connected.

Next, with reference to FIG. **8**, an actual flow of gas will be described.

First, gas flowing from the intake port **11** into the vacuum exhaust device **1**C is compressed in the pump chamber **21**C and exhausted from the exhaust port **41**C. Next, the gas flows in the pump chamber **21**D of the vacuum exhaust device **1**D and is compressed. Then, the gas flows in the pump chamber **21**E of the vacuum exhaust device **1**E directly connected to the pump chamber **21**D. The gas exhausted, from the pump chamber **21**E flows in the path **77***a* of the exhaust-side path **77** formed in the base unit **72**. The gas flow described above is indicated by the arrow F**1** of FIG. **8**.

The gas that has flowed in the base unit **72** flows in the pump chamber **22**D of the vacuum exhaust device **1**D via the pipe member **73**. FIG. **9** shows a flow (arrow F**4**) in which the gas is returned to another pump chamber of the vacuum exhaust device **1**D from the base unit **72** via the pipe member **73**.

The gas that has flowed in the pump chamber **22**D is compressed in a path reaching the base unit **72** as indicated by the arrow F**2** shown in FIG. **8**. Then, the gas that has been compressed in the path indicated by the arrow F**3** shown in FIG. **8** is eventually introduced to the valve unit **74** and exhausted from the exhaust port **12**.

Further, by operation of the plurality of valves **79** provided to the valve unit **74**, exhaust from the pump chamber **21**E or **22**E of the vacuum exhaust device **1**E is allowed.

According to the embodiment described above, provided is a configuration in which the intake ports **32**D and **33**D of the vacuum exhaust device **1**D arranged at one end side among the plurality of connected vacuum exhaust devices and the exhaust ports **41**E and **42**E of the vacuum exhaust device **1**E arranged at the other end side are connected to each other, and thus gas exhausted from the vacuum exhaust device **1**E arranged at the other end side is caused to flow in the vacuum exhaust device **1**D arranged at the one end side.

Accordingly, when a plurality of vacuum exhaust devices including a plurality of pump chambers are connected to compress gas, the degree of freedom in arrangement of the pump chambers is increased. Therefore, in addition to the effects of the first embodiment, a more efficient vacuum exhaust system can be established.

Further, by direct connection of the valve unit **74** to the base unit **72**, exhaust from an arbitrary pump chamber is easily performed. Therefore, it is unnecessary to provide complicated pipe connection and it is possible to achieve compatibility between optimization and downsizing of devices.

Third Embodiment

FIG. **14** is a cross-sectional view showing a vacuum exhaust system according to a third embodiment of the present invention. FIG. **15** is a side view showing a part of a connection unit of the vacuum exhaust system as viewed in a direction perpendicular to a rotating shaft of a rotor of each vacuum exhaust device. A vacuum exhaust system **10**C according to this embodiment and, for example, the vacuum exhaust system **10**B according to the second embodiment described above are different from each other in that the vacuum exhaust system **10**C includes a cooling mechanism.

The cooling mechanism is a cooling pipe **15** that causes a cooling medium to flow therethrough, for example. The cooling pipes **15** are provided at a plurality of positions of each of casings **25**C, **25**D, and **25**E of the vacuum exhaust system **10**C, in motor housings **8***a* of motors **8**, and also in a pipe member **173** as shown in FIG. **15**. The cooling pipes **15** provided to the casings **25**C, **25**D, and **25**E are provided near a bearing and provided so as to be inserted into a partition wall **16** or the like, for example. In the vacuum exhaust device **1**D (**1**E), the partition wall **16** has a function of defining a plurality of pump chambers **21**D to **23**D (**21**E to **23**E) within one casing **25**D (**25**E). Such a cooling mechanism allows the vacuum exhaust system **10**C to be efficiently cooled.

In particular, the cooling pipe **15** is provided to the partition wall **16**, and therefore a casing, which is hard to cool, can be cooled to the inside thereof.

As shown in FIG. **15**, a holding box **173***a* that holds a part of the cooling pipe **15** is connected to a side surface of the pipe member **173**. The cooling pipe **15** is formed into such a U-shape that is turned once within the holding box **173***a*. However, the cooling pipe **15** is not limited to the U-shape, and the designing of the shape or length thereof can be changed.

It should be noted that the cooling pipes **15** provided at a plurality of positions as described above may be configured so as to be connected by one pipe having one inlet and one outlet, that is, configured as a flow path of one system. Alternatively, the cooling pipes **15** may be constituted of a plurality of pipes so as to be configured as flow paths of a plurality of systems.

Fourth Embodiment

FIG. **16** is a view for describing a fourth embodiment of the present invention and is a cross-sectional view showing a structure of a part of a vacuum exhaust system. This is a base unit **172** in which a cooling mechanism is added to the base unit **72** according to the second embodiment described above.

This cooling mechanism includes, in addition to the cooling pipes **15**, cooling fins **115** provided to exhaust-side paths **177***a*, **177***b*, and **177***e*. The cooling fins **115** are formed in a block of the base unit **172** by integral molding, for example. The cooling pipes **15** are arranged at lower portions of those exhaust-side paths **177***a*, **177***b*, and **177***c* and provided to pass through the block of the base unit **172**.

In the vacuum exhaust system, since gas is compressed on the exhaust side, temperature rises on the exhaust side more than on the intake side. The cooling mechanism is provided to the base unit on the exhaust side of the vacuum exhaust system, and therefore heat generated by compression of gas can be cooled efficiently.

In this embodiment, the cooling fins **115** are provided as the cooling mechanism, but the cooling fins **115** may not be provided.

The present technology is not limited to the embodiments described above and can achieve other various embodiments.

The outer shape of the casing **25** is not limited to the elliptical cylinder shape. In particular, the outer shape may be a shape that does not depend on the shape of a pump chamber, for example, a block shape as long as a vacuum pump has a small amount of displacement.

In the embodiments described above, the plurality of vacuum exhaust devices are arranged to be stacked on each other in the vertical direction, but vacuum exhaust devices may be stacked on each other in a horizontal direction or both in the vertical and horizontal directions.

The vacuum exhaust systems according to the embodiments described above each include two or three vacuum exhaust devices, but the vacuum exhaust system may include four or more vacuum exhaust devices arrayed and connected in the vertical and/or horizontal direction(s).

As described above, in the case where the second (third, or fourth) embodiment described above is applied to an embodiment in which three ore more or four or more vacuum exhaust devices are provided, a pipe member having a function of an outer pipe, such as the pipe member **73**, may be connected such that casings of adjacent two vacuum exhaust devices among those four or more vacuum exhaust devices are connected to each other. Alternatively, a pipe member having a function of an outer pipe, such as the pipe member **73**, may be connected such that casings of non-adjacent two vacuum exhaust devices among those four or more vacuum exhaust devices are connected to each other.

In the case where a vacuum exhaust system includes four or more vacuum exhaust devices, for example, a plurality of pipe members having a function of an outer pipe, such as the pipe member **73**, may be provided.

The cooling mechanism shown in FIG. **16** may be provided between, for example, the vacuum exhaust device **1**C at the foremost stage and the vacuum exhaust device **1**D at the next stage as shown in FIG. **8** or **14**.

The cooling fins provided in the cooling mechanism as shown in FIG. **16** may be formed in the partition wall **16** described above.

DESCRIPTION OF SYMBOLS

1A to **1**E vacuum exhaust device
3, **103** intake unit
3*a*, **103***a* end surface
4, **104** exhaust unit
4*a*, **104***a* end surface
5 mount portion
6 leg portion
21 to **24** pump chamber
25A, **25**B casing
25Ba, **25**Ea upper-side casing
25Bb, **25**Eb lower-side casing
31 to **33** intake port
41 to **43** exhaust port
51 first end surface
52 protrusion portion (positioning mechanism)
53 sealing member
61 second end surface
62 positioning hole (positioning mechanism)

The invention claimed is:

1. A coupling structure for a plurality of vacuum exhaust devices, each of the vacuum devices including a pump chamber and a casing that encases the pump chamber, and each of the vacuum exhaust devices including a motor connected to the casing, the coupling structure comprising:

a first end surface formed on a first side of the casing;

a second end surface formed on a second side of the casing, the second side being an opposite side of the first side;

a plurality of mount portions each including the first end surface and each being formed on the first side of the casing; and

a plurality of leg portions each including the second end surface and each being formed on the second side of the casing,

wherein a casing of a first vacuum exhaust device and a casing of a second vacuum exhaust device among the plurality of vacuum exhaust devices are arranged to be directly superposed on each other such that the second end surface provided to the first vacuum exhaust device and the first end surface provided to the second vacuum exhaust device come into contact with each other, and

wherein by fastening the first end surface of the second vacuum exhaust device and the second end surface of the first vacuum exhaust device, the first vacuum exhaust device and the second vacuum exhaust device are connected to each other such that gas flows between the casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device.

2. The coupling structure according to claim **1**, wherein the plurality of vacuum exhaust devices each include

an intake unit including at least one intake port and an intake unit end surface, the at least one intake port communicating with the pump chamber, the intake unit being formed on the first side of the casing, and

an exhaust unit including at least one exhaust port and an exhaust unit end surface, the at least one exhaust port communicating with the pump chamber, the exhaust unit being formed on the second side of the casing,

the casing of the first vacuum exhaust device and the casing of the second vacuum exhaust device are arranged to be directly superposed on each other such that the intake unit end surface of the intake unit and the exhaust unit end surface of the exhaust unit come into contact with and overlap each other, and

by fastening the first end surface and the second end surface, the intake unit end surface and the exhaust unit end surface are directly connected to each other and the intake port and the exhaust port communicate with each other.

3. The coupling structure according to claim **2**, wherein

the plurality of mount portions and the intake unit are independently formed on the casing, and

the plurality of leg portions and the exhaust unit are independently formed on the casing.

4. The coupling structure according to claim **3**, wherein

the intake unit end surface of the intake unit and the plurality of mount portions are formed on the same plane, and

the exhaust unit end surface of the exhaust unit and the plurality of leg portions are formed on the same plane.

5. The coupling structure according to claim **2**, further comprising a sealing member provided to the intake unit end surface or the exhaust unit end surface, the sealing member keeping air sealing inside the casing.

6. The coupling structure according to claim **1**, further comprising a positioning mechanism provided to the first end surface of each of the plurality of mount portions or the second end surface of each of the plurality of leg portions, the positioning mechanism having a concavo-convex shape.

7. The coupling structure according to claim **1**, wherein the casing is formed of a lower-side casing and an upper-side casing.

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